Ref. No.: Ex/ME(M2)/PC/B//T/215/2025

B.E. MECHANICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAMINATION- 2025

Subject: **MATERIAL SCIENCE AND ENGINEERING** **Time : Three hours** **Full Marks: 100**

(Answer any **FIVE** questions)

1(a) Briefly explain the various types of engineering materials. (10)

(b) Explain the following mechanical properties:

(i) Toughness (ii) Fatigue (iii) Creep (iv) Ductility (10)

Or

1.a) Draw force versus interatomic separation curve and show how elastic modulus varies with interatomic bond nature. (6)

b) What is yielding? Discuss the difference between true stress, true strain, and engineering stress, engineering strain with an example where considering engineering strain instead of true strain gives erroneous results. (2+6)

(c) A tensile stress is to be applied along the long axis of a cylindrical brass rod that has a diameter of 10 mm. Determine the magnitude of the load required to produce a 2.5×10^{-3}-mm change in diameter if the deformation is entirely elastic. (6)

2(a) Nickel has FCC crystal structure with atomic radius of 1.245 Å. Determine the followings:

(i) Atomic packing factor

(ii) Linear density along the directions [110] and [111]

(iii) Planner density along the planes (110) and (111). (12)

2(b) Draw the following crystallographic planes and directions:

$(2\bar{1}0)$, $[102]$, $(12\bar{1})$, $[32\bar{1}]$ (8)

3(a) Explain different mechanisms of solid state diffusion. How will you determine activation energy for solid state diffusion ? (6+4)

3(b) For a carburization process, the carbon environment used has carbon content of 1.4%. The initial carbon content in steel is 0.3% and a carbon content of 0.8% is reached at a depth of 0.75 mm from the surface in 10 hours. Determine the carburization temperature. (10)

Given: $D_o = 20\times10^{-6} \frac{m^2}{s}$; $Q = 142 \frac{KJ}{mol}$; $R = 8.314 \frac{J}{mol\,K}$

Z	0.45	0.50	0.55	0.60
erf(Z)	0.4755	0.5205	0.5633	0.6034

4(a) Derive the expression for composite elastic modulus under iso-strain condition for a fibre reinforced composite material. Also mention the assumptions made to derive the expression. (6+3)

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4(b) For a fibre reinforced composite material, the modulus ratio is 26 and the fibre takes 35% of the cross sectional area. What percentage of the longitudinal load is taken by the fibre ? (5)

4(c) Explain the stress-strain behaviour of a fibre reinforced composite under longitudinal loading. (6)

5(a) Show liquidus, solidus and solvus line in a schematic phase diagram with a clear marking of single and dual phase zone in the schematic diagram. Draw the Fe-C phase diagram with according scale and label it mentioning salient points. (3+8)

b) A 5 kg ferrous alloy that contains 2.85 % carbon cooled from liquid phase and undergoes eutectic reaction forming γ-austenite and cementite. Determine the amount in kg of (i) Primary (pro-eutectic) γ-austenite (ii) Eutectic γ-austenite and (iii) Cementite (9)

6(a) Draw and explain the Time Temperature and Transformation (TTT) diagram and explain the important features of this diagram? (12)

6(b) An alloy of 30 kg of Pb-Sn contains 36% Sn by weight. Refer the Pb-Sn phase diagram given in Fig. 1 and determine the followings:

(i) Amounts of solid and liquid phases at 210 °C

(ii) Amounts of pro-eutectic solid and liquid phases

(iii) Amounts of α and β phases formed by eutectic reaction only. (2+3+3)

7(a) Differentiate between 'resolved shear stress' and 'critical resolved shear stress'. Calculate the resolved shear stress on the (111) $[0\bar{1}1]$ slip system of a unit cell in an FCC nickel single crystal if a stress of 13.7 MPa is applied in the [001] direction of a unit cell. Derive the necessary formula. (4+9)

7(b) Mention the objectives of heat treatment. Explain any one heat treatment process. (3+4)

Q8) Write short notes (any four): (4×5)

a) Dislocation motion

b) Lever rule

c) Failure of materials

d) Burger vector

e) Critical length of fibre

f) Miller indices

g) Co-efficient of diffusion

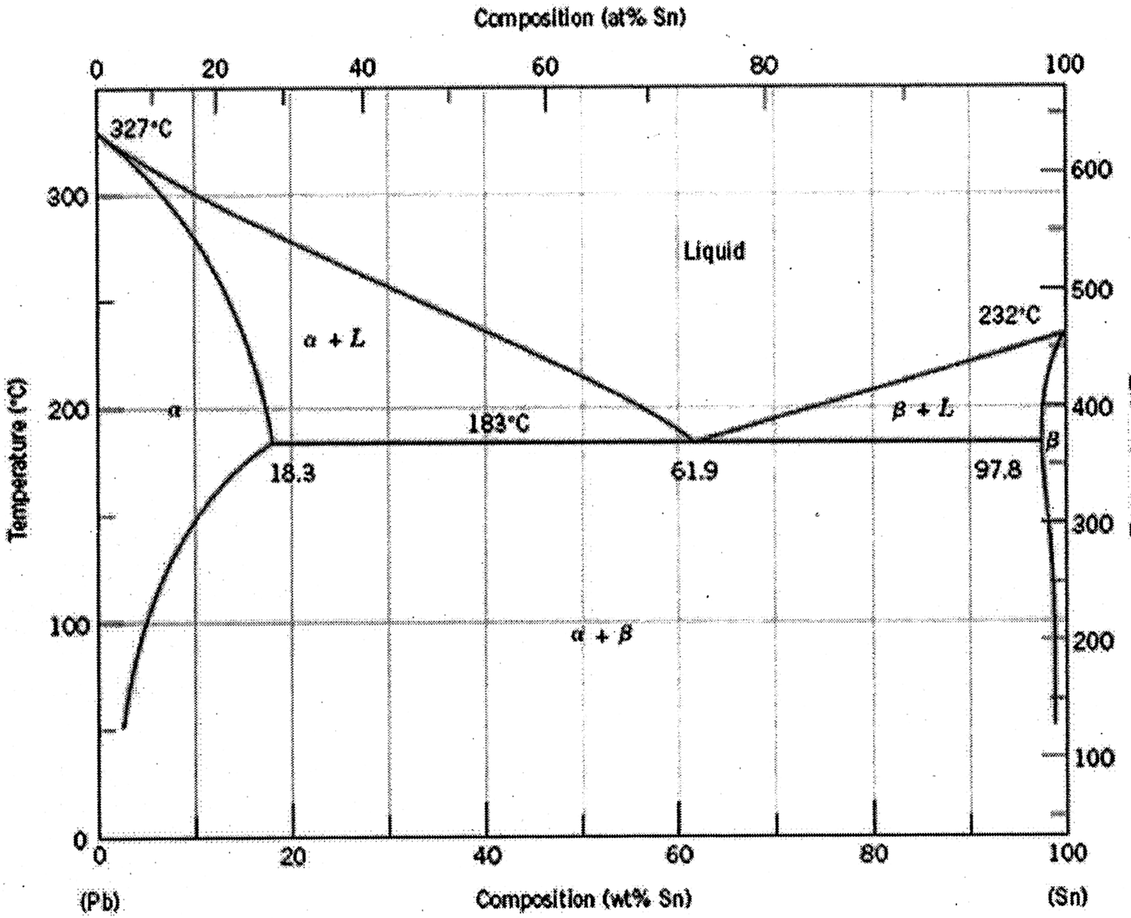
Composition (at% Sn)
0
20
40
60
80
100
327°C
300
200
100
0
Temperature (°C)
Liquid
α + L
α
183°C
β + L
232°C
β
18.3
61.9
97.8
α + β
600
500
400
300
200
100
Temperature (°F)
0
20
40
60
80
100
(Pb)
Composition (wt% Sn)
(Sn)

Fig. 1